Ocean Energy: International overview and Vision

Henry Jeffrey

Edinburgh

November 2017

Structure

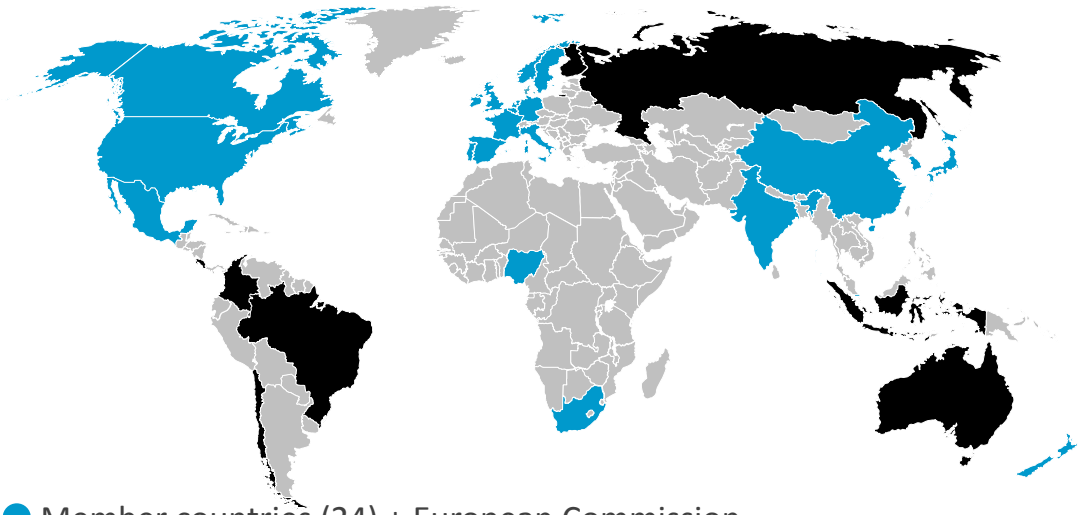
- **IEA International Vision**
- **European Programmes**
- **Country examples**

AN INTERNATIONAL VISION FOR OCEAN ENERGY 2017

INDUSTRIAL GOAL
By 2050, ocean energy has the potential to have deployed over 300 GW of installed capacity.

SOCIETAL GOAL
By 2050, ocean energy has the potential to have created 680,000 direct jobs and saved 500 million tonnes of CO_2 emissions.

Membership diversification



- Member countries (24) + European Commission
- Countries invited to join (8)

Diversified representation of interests in the ExCo

- GOVERNMENTAL DEPARTMENTS
- INDUSTRY ASSOCIATIONS
- UTILITIES
- ENERGY AGENCIES
- GOVERNMENTAL AGENCIES
- RESEARCH ORGANIZATIONS
- UNIVERSITIES

The OES Vision

for International Deployment of Ocean Energy

Utilization of ocean energy resources will:

- Contribute to the world's future sustainable energy supply.
- Supply electricity, drinking water and other products at competitive prices, creating jobs and reducing dependence on fossil fuels.
- Reduce the world energy sector's carbon emissions, whilst minimizing impacts on marine environments.

Ocean energy may experience similar rates of rapid growth between 2030 and 2050 as offshore wind experienced in the last 20 years.

OES GLOBAL OCEAN ENERGY DEPLOYMENT VISION	
Installed Capacity (GW)	**300**
Direct Jobs	**680**
Investment in 2050 year (US$)	**35 Billion**
Carbon Savings (million tonnes of CO2)	**500**

INDUSTRIAL GOAL

By 2050, ocean energy has the potential to have deployed over 300 GW of installed capacity.

SOCIETAL GOAL

By 2050, ocean energy has the potential to have created 680,000 direct jobs and saved 500 million tonnes of CO2 emissions.

Development Themes

› Despite the relatively large number of ocean energy devices which have undergone sea trials, future technical developments will have to address improved reliability and survivability.

› Most critical element to insure that ocean energy technologies become competitive with other energy generation options
› Challenges similar to those that faced offshore wind

› Improve efficiency and performance, and enhanced load factor
› Enhancing operability and access for servicing
› Increase device availability

Cost Reduction

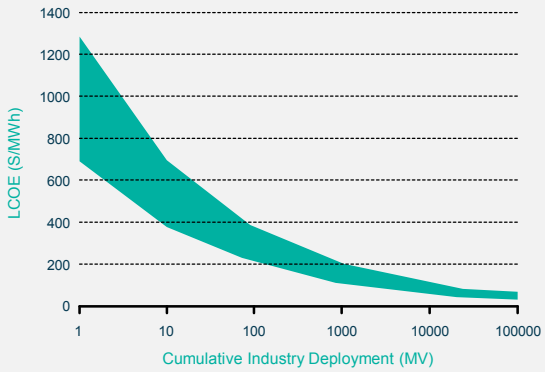
Cost reduction efforts are a critical theme for the successful introduction of ocean energy into a very competitive energy supply

Cost reductions are likely to arise from:

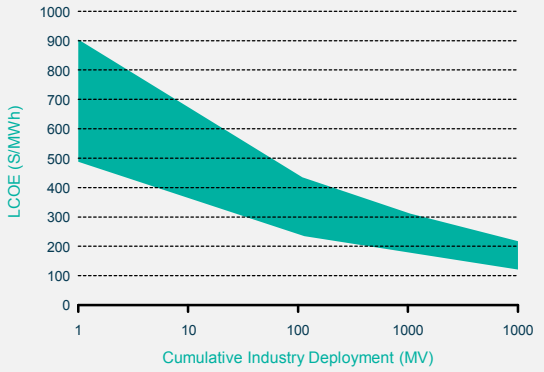
- Manufacturing at scale
- Fundamental design modifications as technologies mature
- Standardization of components, e.g., PTOs, foundations, moorings
- Deployment in arrays (modular development)
- Operational efficiencies: installation, maintenance and recovery
- Performance data gathering for improved reliability and availability
- Integration with other technologies
- Resource analysis and forecasting
- Improved grid and network connections

Learning Curves

WAVE ENERGY



TIDAL CURRENT

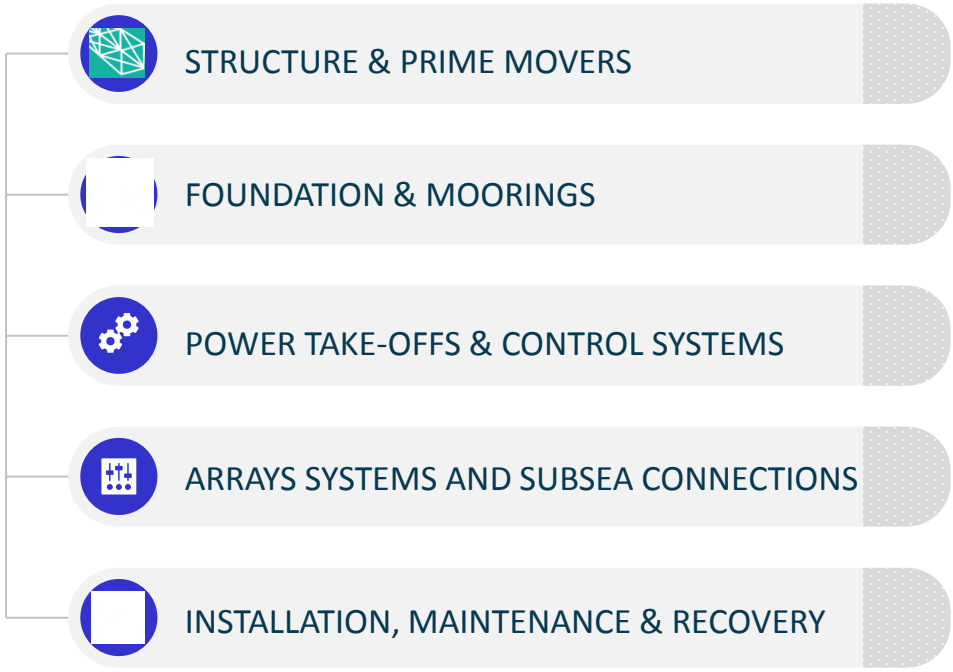


Development Areas

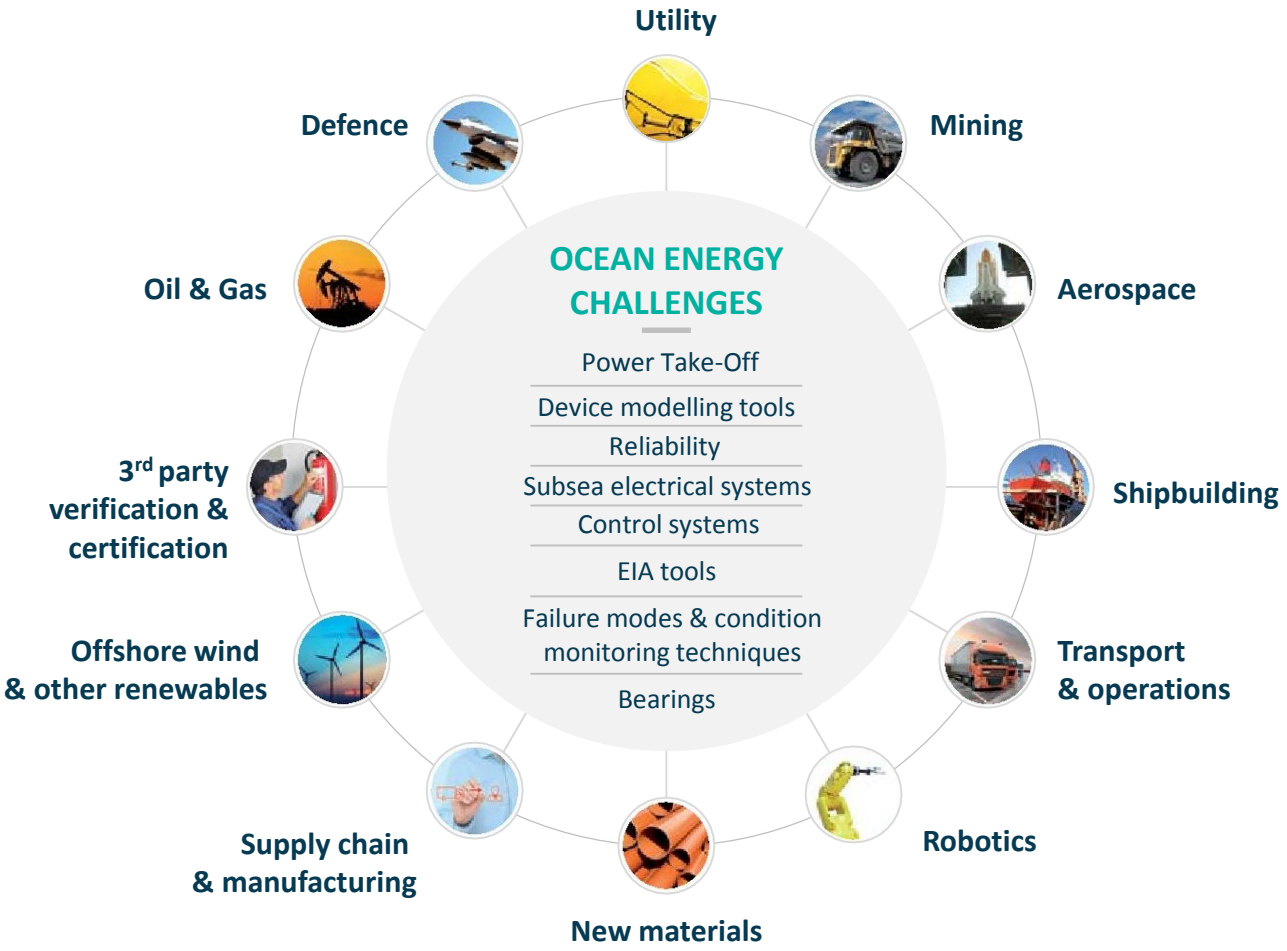
Different devices require different development activities.

Three encouraging developments:

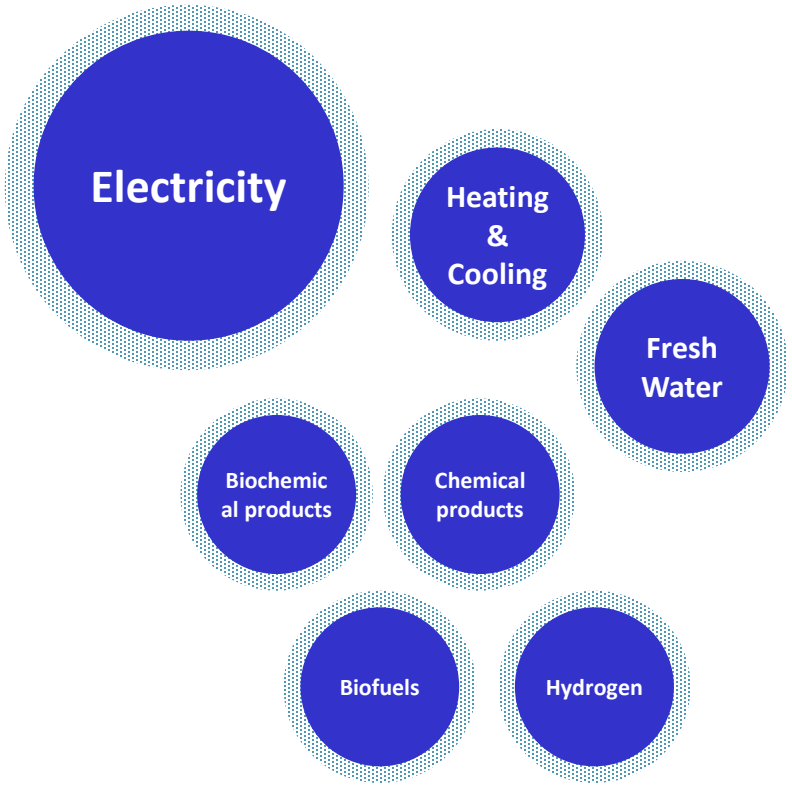
- Increased knowledge and technology transfer
- Spread of industry standards
- Collaboration between competing device developers to design common components, e.g., power take-offs.



Technology Transfer



Products and Markets for Ocean Energy



Utility-scale grid electricity generation

Islands electricity generation

Heating, Cooling and Desalination

Off-Grid Applications (remote locations)

Structure

- **IEA International Vision**
- **European Programmes**
- **Country examples**

European Commission

#InvestEUresearch

Horizon 2020 Work Programme for Research & Innovation 2018-2020

DG Research and Innovation

unit Renewable Energy Sources

Research and Innovation

LC-SC3-RES-1-2019 (-2020)

Bringing these new energy conversion solutions, new renewable energy concepts and innovative renewable energy uses faster to commercialization

Type of action:

RIA to TRL 3-4

Budget:

EUR 20 million

Project funding:

EUR 2-5 million

Deadline:

16/10/2018 +25/4/2019

2 stage procedure

Developing the next generation of renewable energy technologies

Subchallenges

-The challenge is to develop energy technologies currently in the early phases of research. Developments in sectors other than energy may provide ideas, experiences, technology contributions, knowledge, new approaches, innovative materials and skills that are of relevance to the energy sector

Expected impact: On its completion, the project is expected to advance the knowledge and prove the technological feasibility of the concept including the environmental, social and economic benefits.

European Commission

LC-SC3-RES-11-2018

Achieving or maintaining global leadership in renewable energy technologies requires cost reductions

Type of action: RIA TRL 3-4 to 4-5

Budget:

EUR 30 million

Project funding:

EUR 2-5 million

Deadline

31/1/2018+ 23/8/2018

2 stage procedure

Developing solutions to reduce the cost and increase performance of renewable technologies

Subchallenge

Ocean: New integrated design and testing of tidal energy devices with behavioural modelling to achieve extended lifetime and high resistance in marine environment

Expected impact: the proposed solution will reduce the CAPEX and/or OPEX of energy generation from any of the mentioned renewable sources making it comparable to generation costs from competing fossil fuel sources.

European Commission

LC-SC3-RES-14-2019

Optimisation of several key processes in their respective value chains

Type of action:
RIA TRL 3-4 to 4-5

Budget:

EUR 20 million

Project funding:

EUR 3-5 million

Deadline

16/10/2018 + 25/4/2019

2 stage procedure

Optimising manufacturing and system operation

Monitoring system for marine energy (ocean and offshore wind) New intelligent sensors, fault detection and communication systems for accurate condition and structural health monitoring will enable predictive and preventive operation and preventive maintenance processes; crucial for innovative wind farm control and the realization of virtual power plants. Sufficient knowledge of potential failures and the right tools to detect and locate failures are crucial.

Expected impact: The improved performance of manufacturing processes and system operation is expected to lead to increased efficiency of the system and/or reduced operational costs of the renewable technologies.

European Commission

LC-SC3-JA-3-2019: European Pre-Commercial Procurement Programme for Wave Energy Research &Development

- ***The challenge is:***
- **The design, development and validation of cost-effective Wave energy convertors that can survive in a harsh and unpredictable ocean environment as the ocean through demand-driven Pre-Commercial Procurement.**
- **The challenge is open to proposals seeking to steer wave energy research and development in an effective way at a European level establishing convergence of wave energy technologies and to bring these technologies to the market.**

European Commission

SME instrument

Several cut-off dates per year.

Business innovation grants for feasibility assessment purposes (optional phase I): EUR 50,000 (lump sum) per project (70% of total cost of the project);

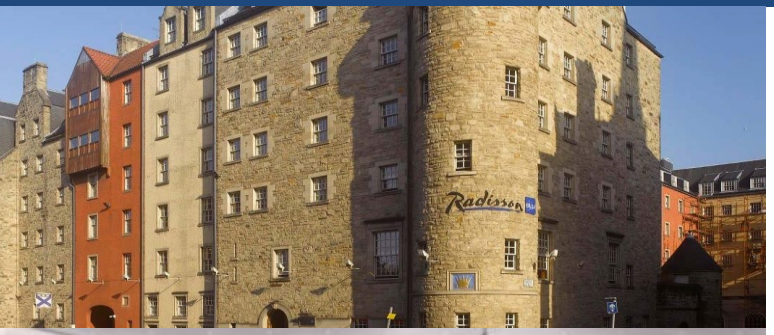
Business innovation grants for innovation development & demonstration purposes (possible phase II): an amount in the indicative range of EUR 500,000 and 2,5 million (70% of total cost of the project as a general rule);

Free-of-charge business coaching (optional) in order to support and enhance the firm's innovation capacity and help align the project to strategic business needs;

Access to a wide range of innovation support services and facilitated access to risk finance, to facilitate the commercial exploitation of the innovation.

OCEANERA-NET Final Conference

Edinburgh 30th & 31st January 2018



Radisson Blu, Edinburgh.

Free to attend, all welcome!

www.oen2018.eu
#oen2018
darren.hill@ktn-uk.org

Breaking Through : Innovation & Collaboration in Ocean Energy

This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No. 618099

Structure

- **IEA International Vision**
- **European Programmes**
- **Country examples**

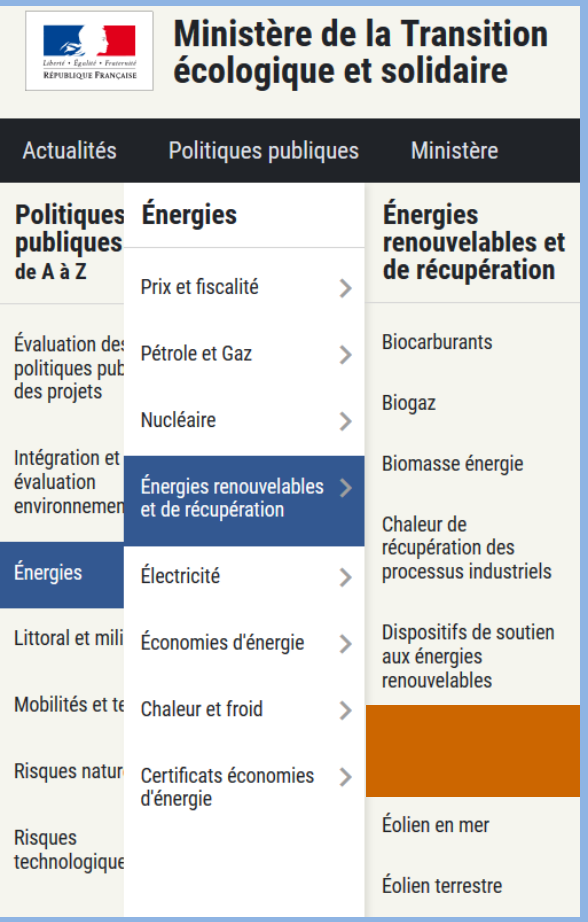
Structure

- France
- Ireland
- Mexico
- Korea
- United states

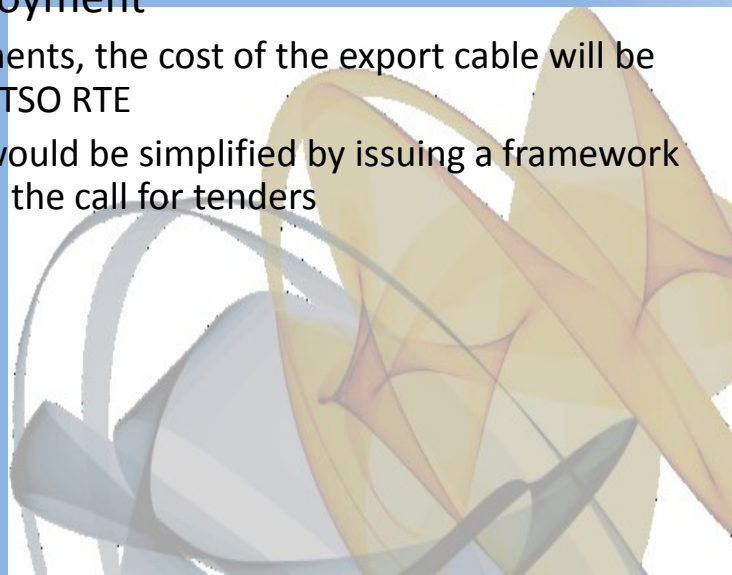
www.france-energies-marines.org

1. SUPPORTING POLICIES FOR OCEAN ENERGY

2. OPEN SEA TEST SITES
3. RESEARCH & DEVELOPMENT
4. TECHNOLOGY DEMONSTRATION
5. OTHER RELEVANT NATIONAL ACTIVITIES



- Ministerial facts & announcements
  - Ongoing update of the targets of the “Pluri-annual Energy Policy”
    - Timeframe: 2018-2028, milestone 2023
    - Figures to be defined: *XX* MW installed, *YY* MW consented
  - A new law is being discussed to favour renewable energies by ***simplifying*** their deployment
    - For all offshore developments, the cost of the export cable will be supported by the French TSO RTE
    - The consenting process would be simplified by issuing a framework permit for the site before the call for tenders



2. OPEN SEA TEST SITES

News from:

- SEM-REV
- SEENEOH
- BREST Ste Anne
- BREHAT

2. OPEN SEA TEST SITES

FLOATGEN Hook Up

- Towing in
- Mooring hook up
- Electrical connection (equipement + operation)

FORESEA first demonstrators

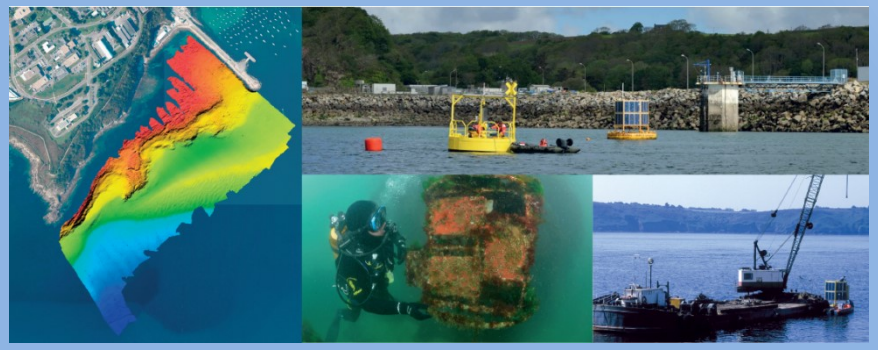
- IHES (GEPS Techno)
- iBOCS (FMGC)
- FLEXSENSE

S3 project setup:

- Direct energy conversion:
- Electro active polymers (EAP)
- Rubber tube filled with water
- 100 m long, 1 m diameter

2. OPEN SEA TEST SITES

Brest Saint-Anne
Test site
for scaled projects



PH4S project (GEPS Techno)

Tests to optimize the management of the 4 energy sources (wave, tidal, solar & wind) - 2017

SCENES

Scientific buoy integrating wave energy conversion. Tests performed prior to operational deployment - 2017

Towing of the PH4S buoy on site

PH4S buoy on site during tests

All pictures credit Ifremer/M. Répécaud

Eolink 10 (Eolink)

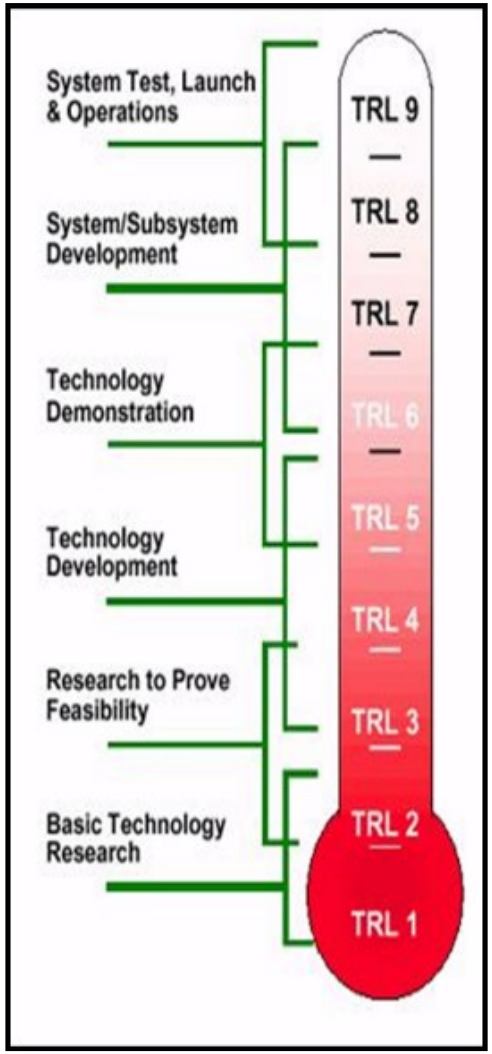
Tests of an innovative floating offshore wind turbine scale 1/10 planned in 2018

5. OTHER RELEVANT NATIONAL ACTIVITIES

Projects supported 2016/2017

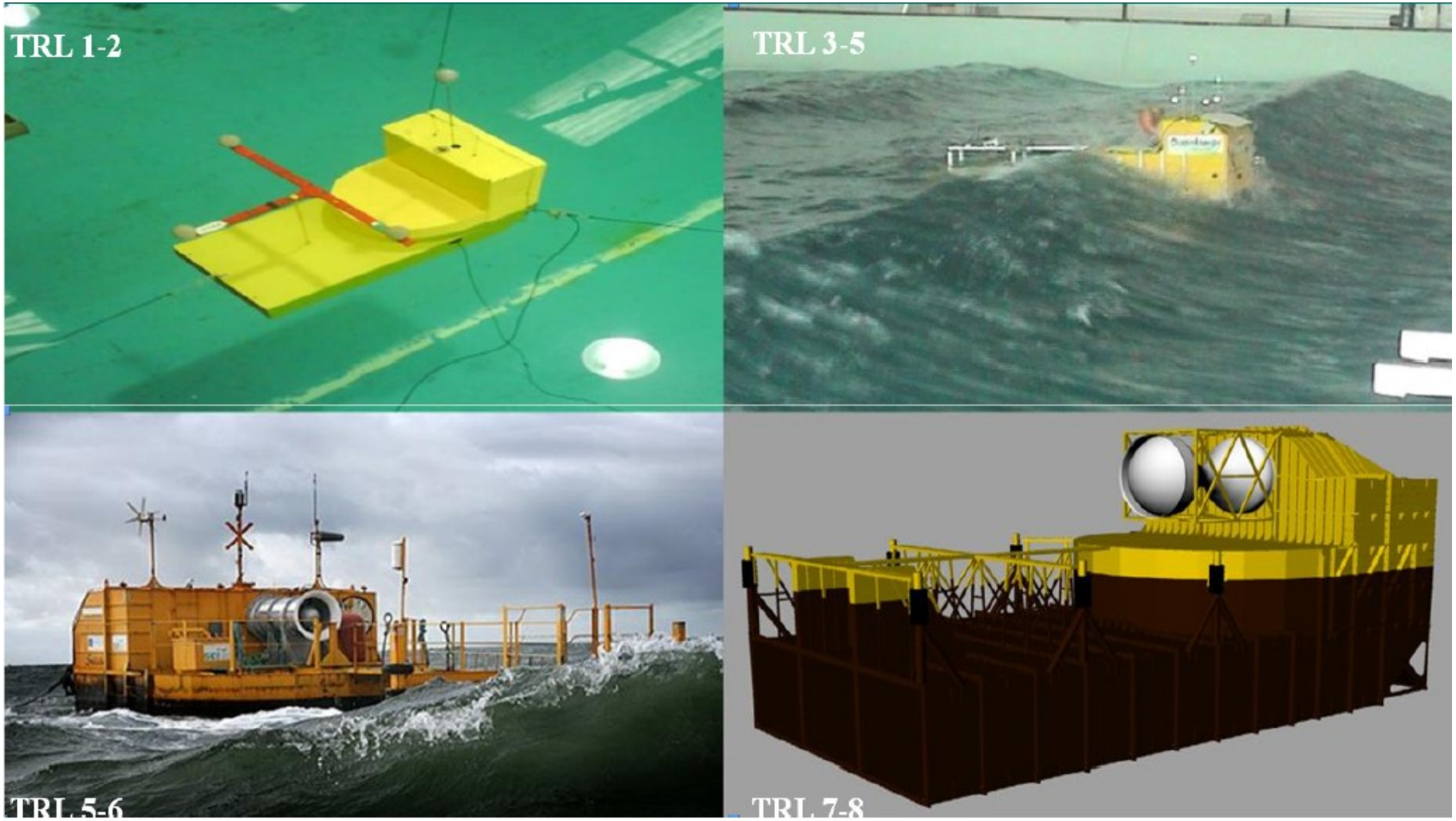
Prototype Fund – range of projects

- Development and testing of wave and tidal energy devices and components
- Commissioned reports and data dissemination
- Consent requirements
- 100 projects supported since 2009
- €14M Grant Aided
- 25 projects currently in process



Ireland Prototype Projects

OE Buoy



Ireland Prototype Projects

Sea-Power

Test Facilities

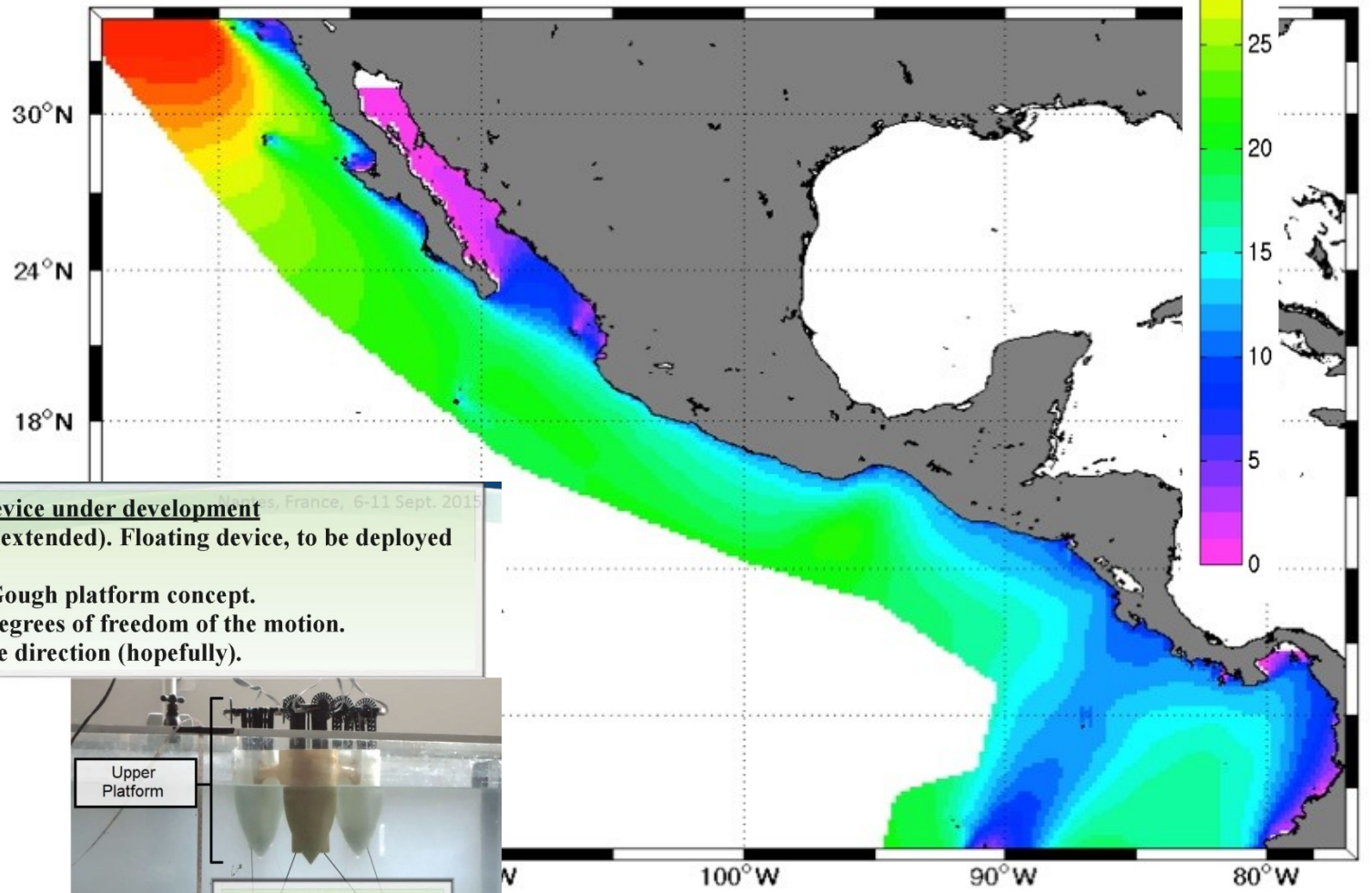
CEMIE-Océano

Mexican Center for Innovation in Ocean Energy

CEMIE-Océano

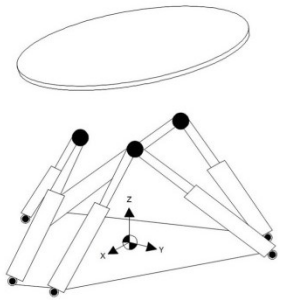
Waves

Average wave power along the Eastern Tropical Pacific 1994-2012.



Brief description of WEC device under development

Mechanical point absorber (extended). Floating device, to be deployed and moored nearshore.
Inspired from the Stewart-Gough platform concept.
Intention to exploit the sig degrees of freedom of the motion.
Regardless of incoming wave direction (hopefully).

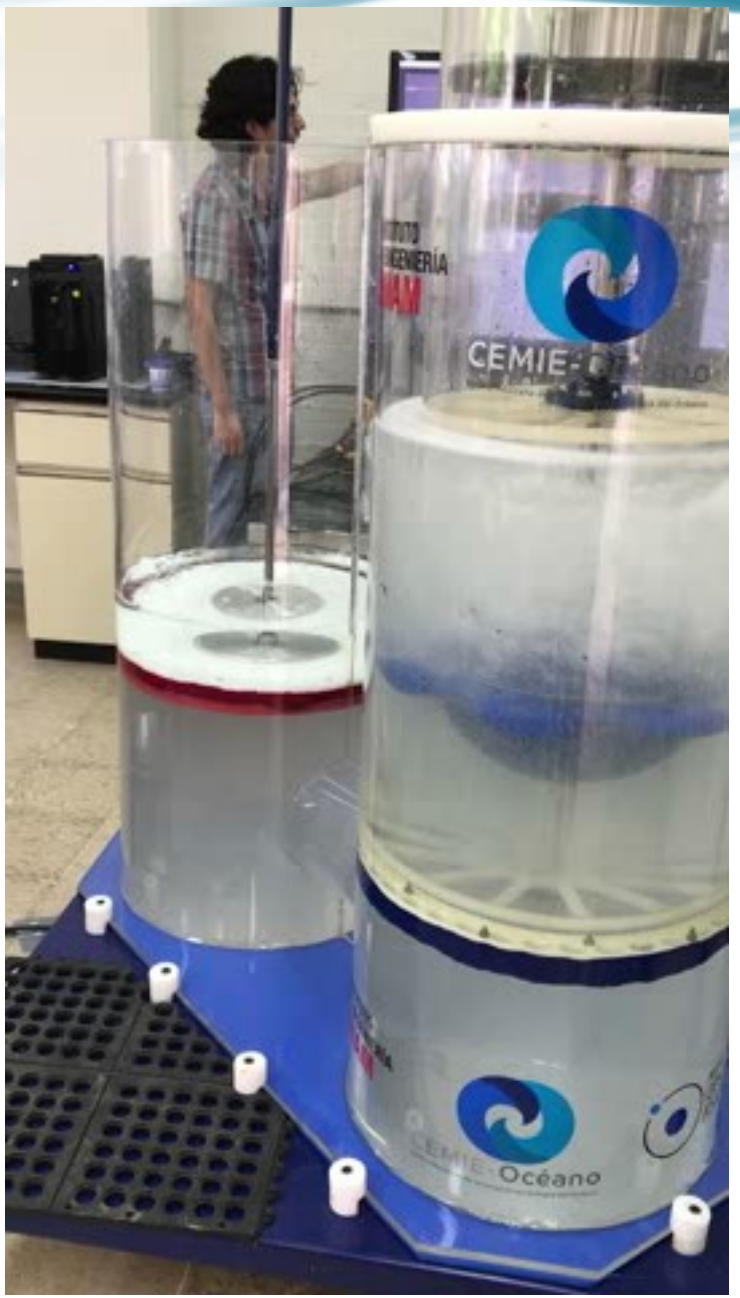


Davliakos & Papadopoulos, 2008, Mechanism and Machine Theory

CEMIE-Océano

Testing devices

System for cathodic protection with neodymium permanent magnet and Wells turbine



KOREA

2030 strategy of Ministry of Oceans and Fisheries (MOF)

- Energy Policy of President Moon Government

  Strategy (20% of national electricity demand from renewable resources by 2030) for reducing CO2 emission, solving fine dust issue, etc.

- MOF is planning to construct large-scale ocean energy farms to follow up the governmental energy policy including wave energy, tidal current energy and wave-wind/tidal current-wind hybrid energy farms in several hundred MW total installed capacity after 2025.

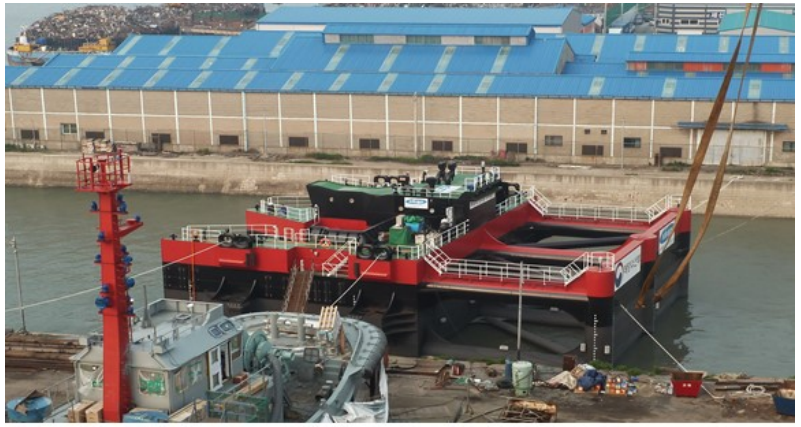
Key Actions

- Priority on infrastructures and accelerating commercial development
- Construction of open sea testing facilities for wave and current energy converters
- Activating open sea tests of WEC & TEC pilot plants
- Enhancing promotion policy on ocean energy by adjusting the REC for WECs and TECs
- Training program for graduate students in ocean energy systems

R&D ACTIVITIES-2

Floating Pendulum WEC (Dr. Seungho Shin@KRISO)

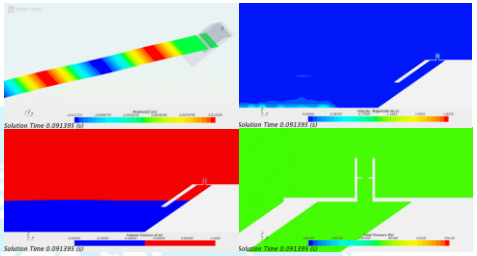
- Principal specification
  - Dimension: 23m (B) x 30.5m (L) x 10m (H)
  - PTO : Hydrostatic Power Transmission
  - Synchronous Generator(300kW)
  - 4 Points 8 lines Catenary mooring
  - Grid Connection
- Key schedule
  - R&D Periods : Aug. 2010~
  - Completion of Prototype Pilot Plant : May. 2016 (now waiting for Real sea test)
  - Installation and Real sea demonstration at Jeju Wave energy test site : June 2018



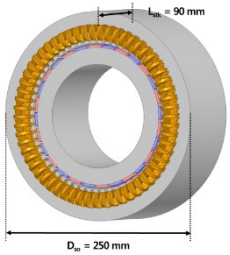
R&D ACTIVITIES-3

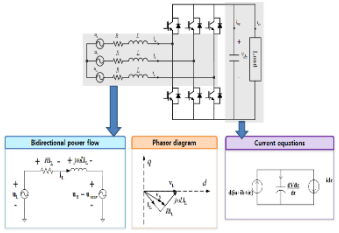
Basic Design of Wave Energy Converter applicable to Breakwater (2016~2017)

- Sloped OWC : Principal dimension, arrangement of OWCs
- Impulse Turbine : Principal dimension, effect of sweep angle & ring
- Generator(PMSG)/PCS : Pole & slot design, generator- & grid-side controller
- ESS/Micro-Grid : Load analysis, PCS design, operational plan, SCADA control level

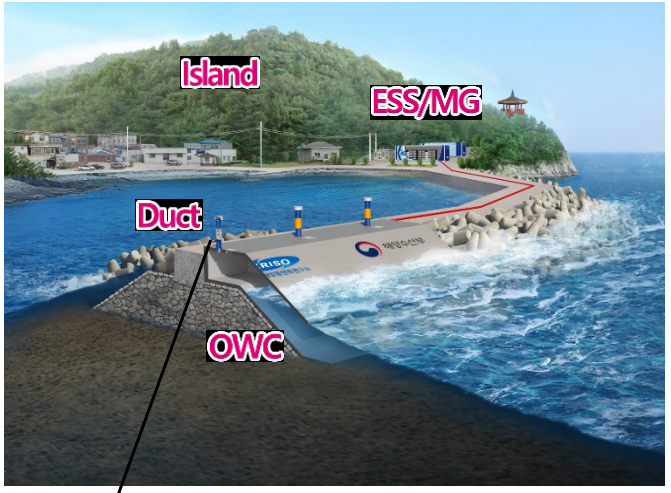


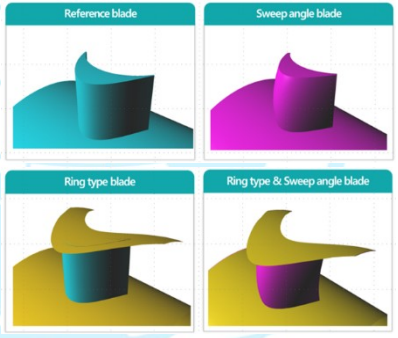
Sloped OWC



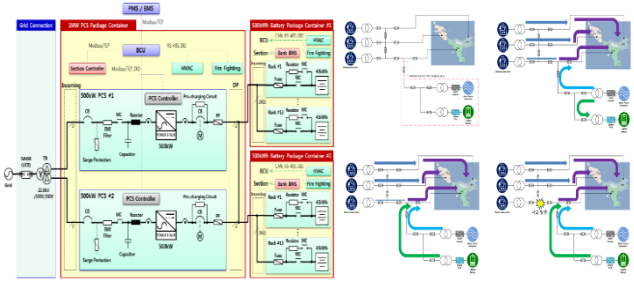


Generator/PCS

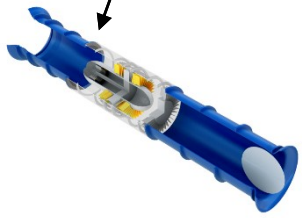




Impulse Turbine



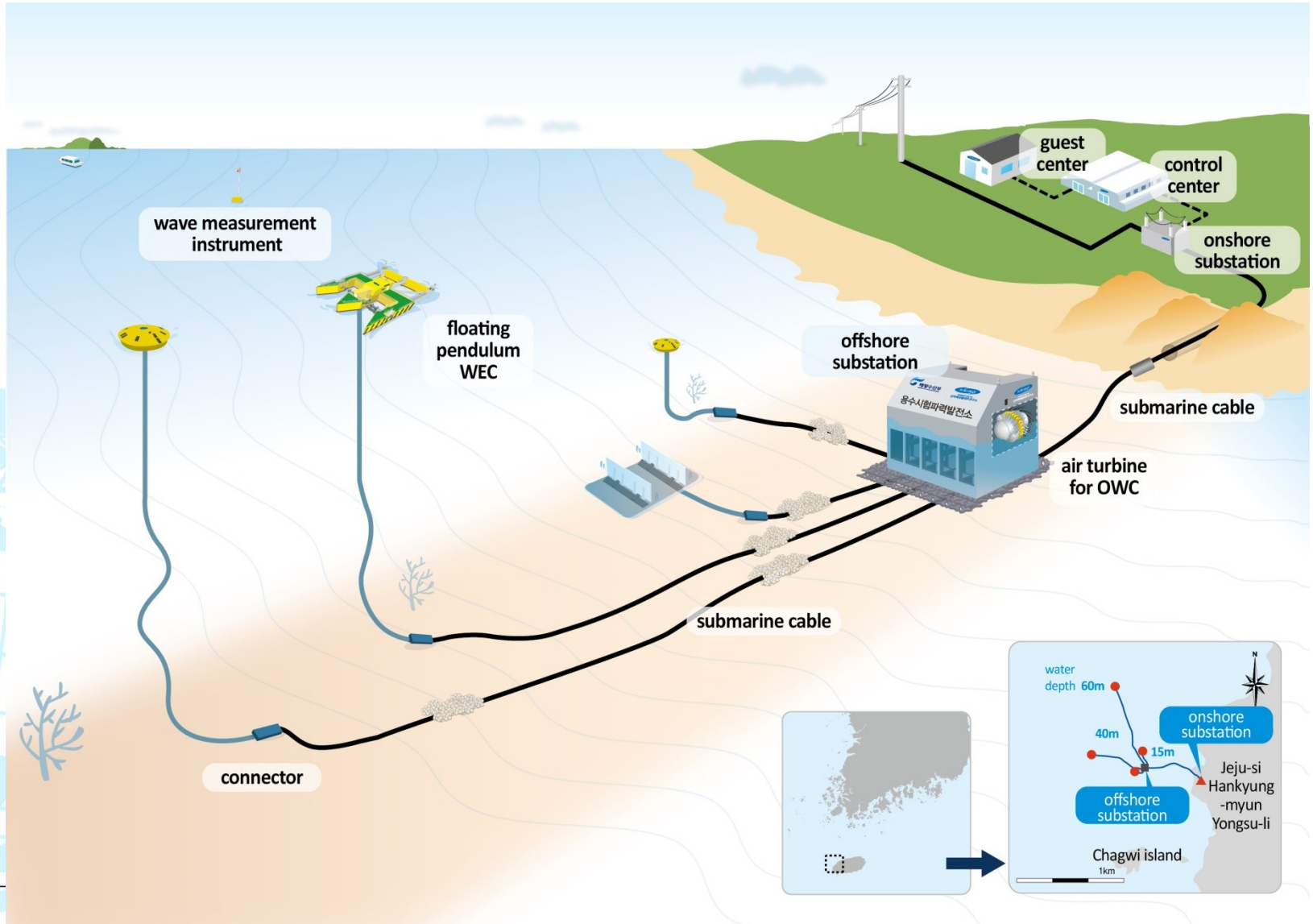
ESS/Micro-grid



Turbine & Generator

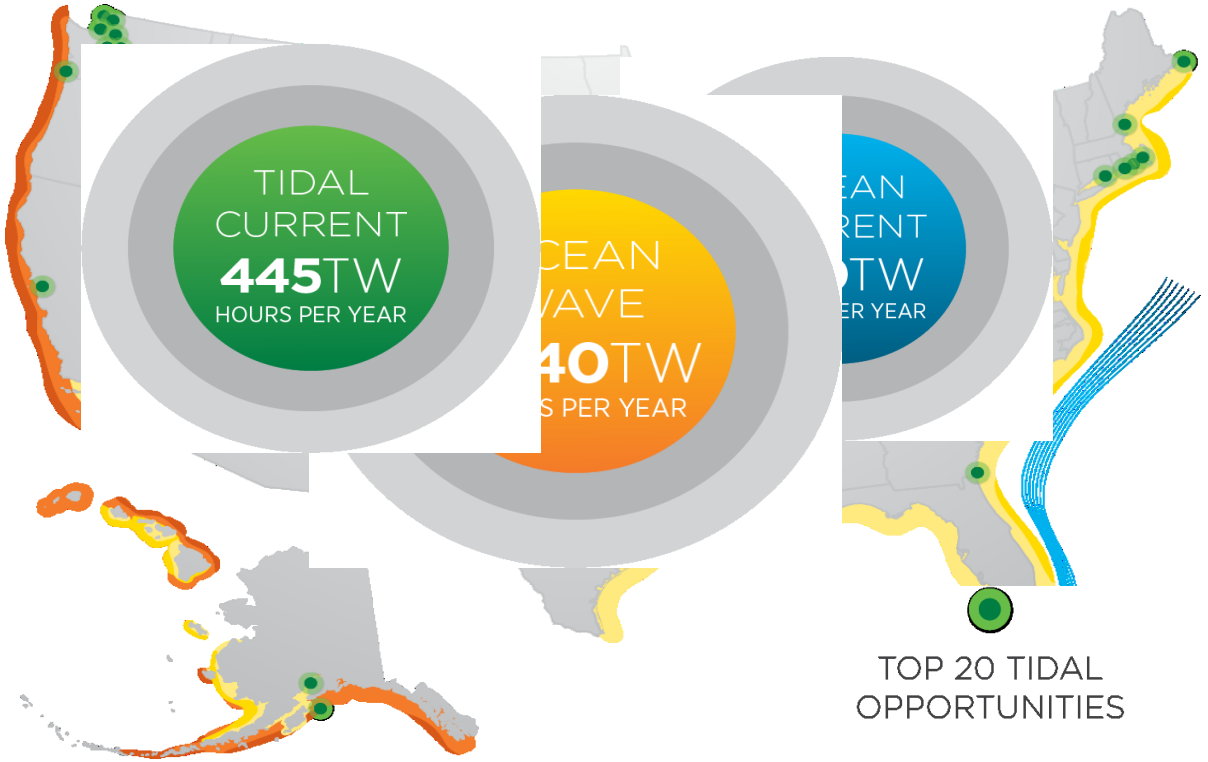
R&D ACTIVITIES-4

K-WETEC (Korea Wave Energy Test Center)



US Marine Energy Market

Marine energy resources in the U.S.



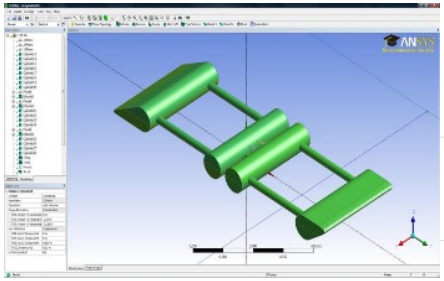
WAVE ENERGY INTENSITY

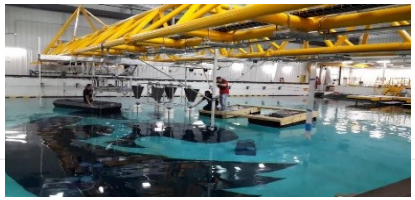
TOP 20 TIDAL OPPORTUNITIES

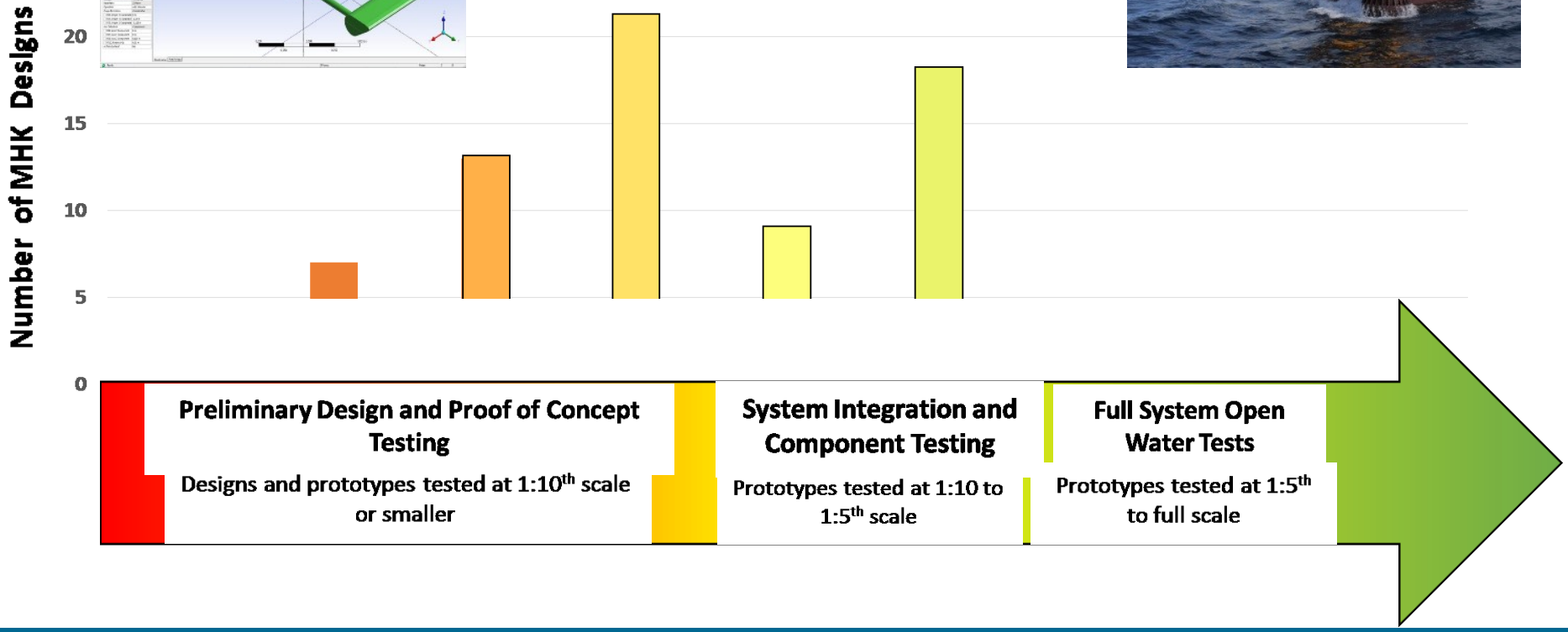
- Create jobs
- Strengthen energy security
- Revitalize seaports
- Increase domestic manufacturing

U.S. Marine Energy Pipeline

DOE is focused on developing a healthy pipeline of marine energy projects, from component and system design to tank testing to open water tests.







Test Site Locations

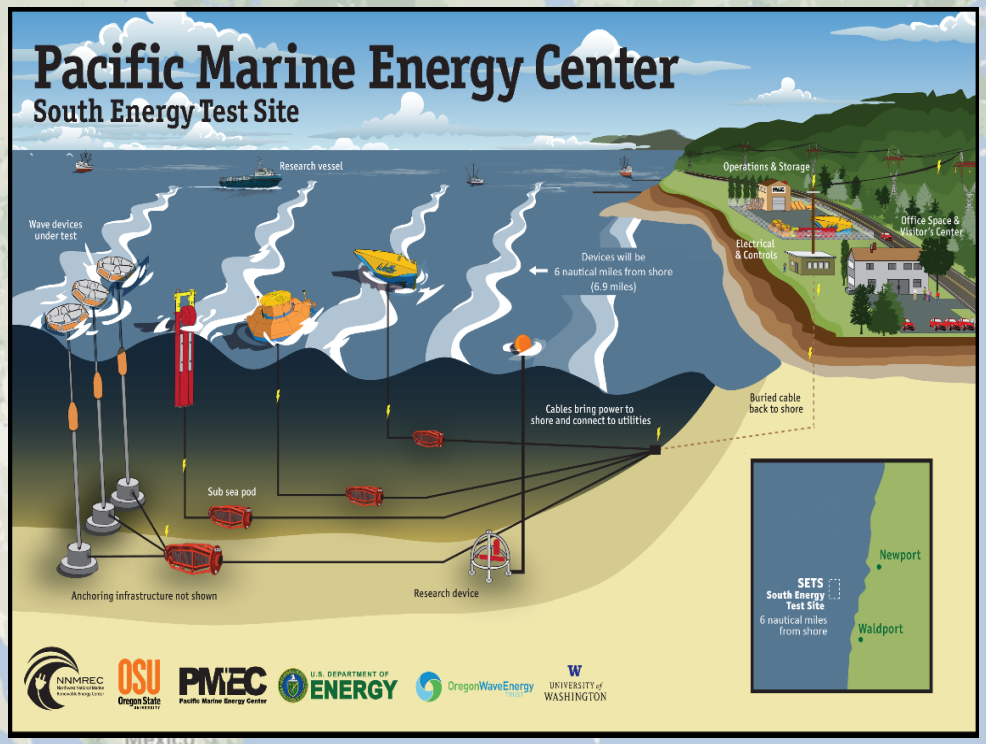
Lab Testing Facilities

Ocean Testing Facilities

The U.S. has 41 unique testing sites and facilities throughout the country that can accommodate devices ranging in size from prototype to utility-scale.

- Led by Oregon State University, co-located with Hatfield Marine Sciences Center + wave tank
- Nearby availability of marine logistics and port facilities
- Fully permitted and grid connected
- High wave energy resources
- Four-berth test site
- Max of 20 WECs at site
- Total capacity: 20 MW

New four-berth, 20 MW facility coming in 2021-2022



U.S. Navy Marine Energy Priorities

The U.S. Navy also has a long-standing marine energy R&D program

- Congress has appropriated $90+ million over the past 10 years for Navy marine energy R&D.
- Full and scale devices are now deployed at U.S. Navy Wave Energy Test Site (WETS) expansion to 3 berths completed in 2015.
- Funded tidal energy R&D activities in the Puget Sound (Univ. of WA and Verdant Power).
- Supported study of global Navy facilities that have wave/tidal energy potential

Join us in Washington DC April 30-May 2

International Marine Energy Conference
Marine Energy Technology Symposium

http://www.waterpowerweek.com

Summary: Ocean energy is a priority

- European and International overview
- Continued high level political support for development of marine energy
- Support across the TRL levels
- Tech Push and Market Pull
- Knowledge and information sharing

THANK YOU

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